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Alarming Acidic Nature of Rainwater in the Industrial zone of Visakhapatnam and its Implication.

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ABSTRACT

Industrialization began in the city of Visakhapatnam from 1950 onwards resulting in transfer of cations and anions to atmosphere. In particular, the commissioning of Steel plant, Chemical factory and Simhadri Thermal Power Corporation (STPC) during the period 1983 to 2003 polluted the 'industrial atmosphere' hazardously. The pH of rainwaters showed a steady decline from basic nature to a critical acidic value of 4.0. The alkaline agents like NH_4 and Ca failed in vain to neutralize the major acidic agents like NO_3 and SO_4. The ratio, $SO^-_4 + NO^-_3 / NH^+_4 +$ Ca+, which was <1 during 1980s, reached a range of 2.0 to 5.9 by 2005. The average electrical conductivity also supports, the phenomenon with its ascent from 45μs/cm in 1983 to 156 μs/cm in 2005. Remedial measures need to be taken on priority, to arrest irreversible damage.

INTRODUCTION

Rainwater serves as a collector of many minor constituents of the atmosphere. Chemical analysis of bulk precipitation (Heij & Erisman, 1995) helps to reveal the composition of the air in which the rain-bearing clouds have been formed. The dust rising from the anthropogenic activity on the surface fills the air. Population growth, increase of vehicular traffic and industrialization (Banerjee, 2008) cause large emissions of SO_4 and NO_3, which when 'washed down' increase the acidity of rainwater. The acid content of the rain has steadily risen in many parts of the world (Medha et al., 2002) for several years, with progressive industrialization.

Acid rain is one of the worst environmental concerns, all over the world. It is termed as 'acid rain' when the pH of the rainwater solution is < 4.0. The 'acid rain' is a complicated effect, caused by air pollution. The oxides of Sulphur and Nitrogen are emitted by burning of natural gas, oil and firewood as well as industrial effluents (Maske and Krishnand, 1982). Inhibiting the plants growth, discoloration of buildings and major structures and affecting the life cycles of micro organisms are some of the consequences of acid rain. Many workers have reported the hazardous nature of acid rains (Postma, 1970) throughout the world.

Present work

The present work involves analysis of rainwater solution from the industrial zone of Visakhapatnam. The city is studded with major industries like Hindustan Zinc Limited (HZL), Coromandel Fertilizers Limited (CFL), Hindustan Petroleum Corporation Limited (HPCL), Bharat Heavy Plates and Vessels (BHPV), Hindustan Polymers Limited (HPL), Steel plant, Coastal Chemicals (CC), Andhra Cement Company (ACC) and Simhadri Thermal Power Corporation (STPC). The industrial development, initiated after 1950 caused the 'population explosion' in Visakhapatnam, which expanded from 0.6 million in 1983 to about 2.2 million in 2003 (Table 1).

About 200 ancillary units rose in the industrial corridor to feed the main industries, which turned the central basin of Visakhapatnam into an air-polluting chimney (Subbarao & Subbarao, 1994). The dust load in the sky is found to be high during the 'dry' periods, which results in an increase of ionic content in rainwater. Coastal spray adds some more elements (SO_4, Ca and Mg) to the existing industrial 'fire'. Figure 1 describes the setting of Industries in Visakhapatnam.

Combustion of large quantities of chemicals in industries like Zinc plant, Fertilizer plant (Nitrogen, Phosphate and Potassium), Polymers, Cement manufacture, Steel production unit and HPCL release pipes of smoke into air. Number of studies in the past have indicated the wash-out of SO_2 and NO_2, which are supplied by vehicular traffic and fuel combustion. Sarma and Subbarao (1972) registered the behavior of rainwaters of Visakhapatnam in 1970 itself. They observed that the ionic activity of the washed-down solution is more in summer than in winter (after the rainy season).

Data Collection and Analysis

Acid rain studies have been carried out by Indian Institute of Tropical Meteorology (IITM), Pune for the

Table 1: Establishment of major industries and growth of population in Visakhapatnam.

S. No.	Name of the Industry	Year	Population
1	Visakhapatnam Port Trust (VPT)	1950	1,08,042
2	Hindustan Petroleum Corporation Limited (HPCL)-Crude Oil refinery	1957	2,11,456
3	Coromandal Fertilizers Limited (CFL)	1967	-
4	Bharat Heavy Plates and Vessels limited (BHPV)	1971	-
5	Union carbide (UC)	1971	3,63,467

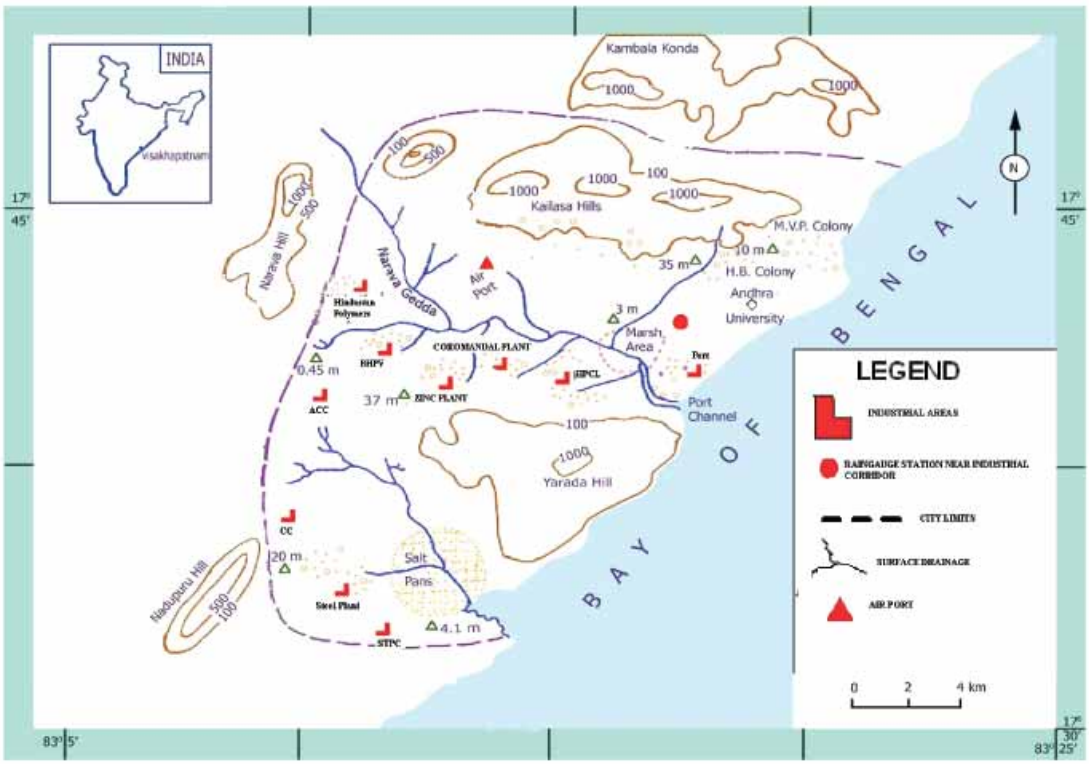

Figure 1. Location of major Industries in Visakhapatnam.

last three decades in various parts of the country. The present work is an analysis of the data of the average annual pH, Electrical conductivity (Ec) and SO_4, NO_3, NH_4 and Ca of rainwaters for Visakhapatnam over a period from 1983 to 2005.

The India Meteorological Department (IMD), Visakhapatnam, collects the monthly 'bulk precipitation' of rainy days and sends it to IITM for chemical analysis. The data of pH, Ec the major two cations and two anions for the period of 1983 to 2005 was obtained from IITM, Pune. The annual average values calculated for the 22 year period are given in Table 2.

Further the ratios of $SO^-_4 + NO^-_3 / NH^+_4 + Ca^+$ for every year are given in the table from 1986 onwards. The ratios, greater than 1 indicate the superior activity of the acid bearing ions of NO_3 and SO_4 in spite of the alkaline elements like Ca and NH_4. Though the ratios are fluctuating, they crossed the equality limit of '1' and reached the range of 5-7. This is responsible for the pH to record 'lower' trends.

DISCUSSION

The data of Table 2 for pH and Ec variations is represented in Fig. 2, where the two variables compliment each other to record the 'impending' disaster in the industrial atmosphere. The average electrical conductivity has steadily risen from a value of 45 μs/cm in 1983 to 156 μs/cm in 2005, suggesting an over all increase of particulate load due to the bulk of industrial line-up. The pH values, however, show some fluctuation, despite an overall decreasing trend from 6.59 in 1983 to 4.2 in 2005. The danger mark of acidity (pH < 4.0) is looming large on the head of the industrial sky (Linkens et al., 1979). This mark

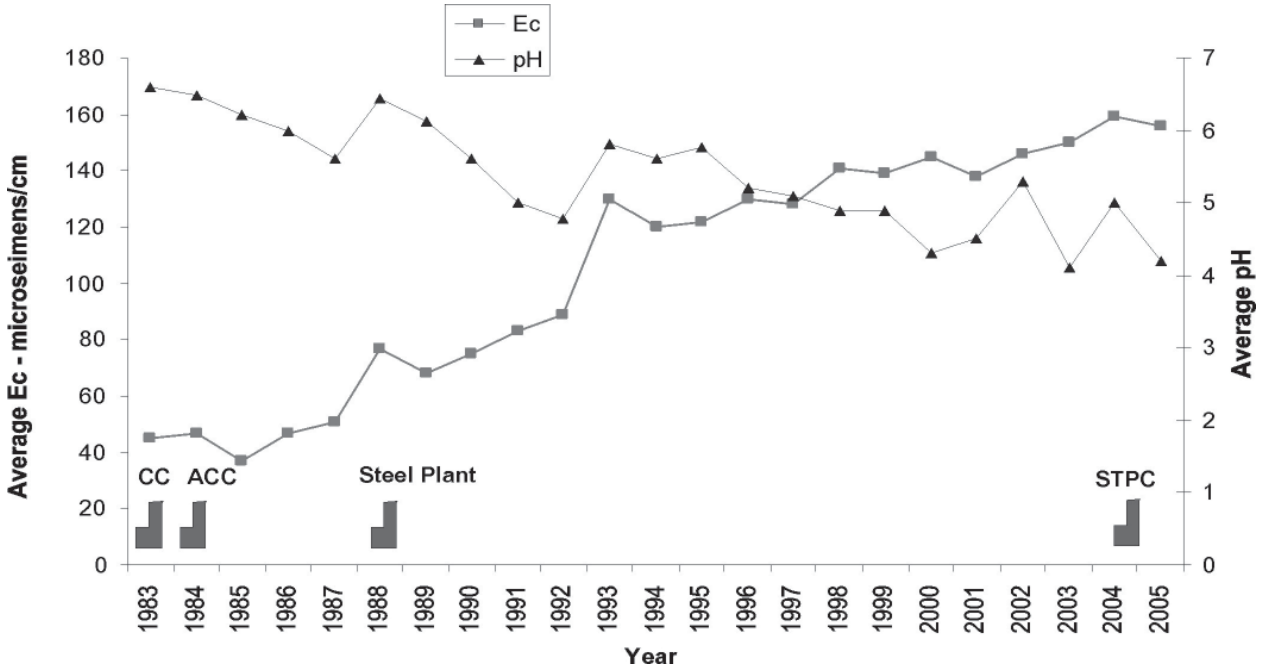

Figure 2. Long time Variations of annual average Ec and pH values during the period, 1983 to 2005.

Table 2. Annual average values of Ec, pH, major acidic and alkaline agents for the years 1983 to 2005.

Year	pH	Ecμs/cm	SO^{-}_{4} mg/l	NO^{-}_{3}mg/l	NH^{+}_{4}mg/l	Ca^{+}mg/l	$(SO^{-}_{4}+NO^{-}_{3})$ /$(NH^{+}_{4}+Ca^{+})$
1983	6.59	45	-	-	-	-	-
1984	6.482	47	-	-	-	-	-
1985	6.21	37	-	-	-	-	-
1986	6	47	1.151	5.68	0.26	7.75	0.85
1987	5.6	51	1.438	11.04	0.02	3.62	3.42
1988	6.45	77	1.511	5.25	0.43	2.44	2.35
1989	6.13	68	1.402	7.80	0.63	5.37	1.53
1990	5.61	75	1.521	11.50	0.76	2.62	3.85
1991	5	83	2.66	19.37	1.02	2.60	6.08
1992	4.77	89	1.88	26.38	0.93	2.92	7.34
1993	5.8	130	1.65	12.43	3.90	14.09	0.78
1994	5.6	120	1.91	35.33	1.33	6.95	4.49
1995	5.77	122	9.73	9.33	6.25	2.77	2.11
1996	5.2	130	3.90	5.21	0.74	1.83	3.54
1997	5.1	128	7.39	8.19	0.50	7.02	2.07
1998	4.9	141	11.10	14.65	0.35	10.60	2.35
1999	4.9	139	6.11	11.95	0.82	2.74	5.07
2000	4.3	145	7.97	17.47	1.11	3.85	5.12
2001	4.5	138	7.96	6.53	2.36	2.19	3.18
2002	5.3	146	12.34	10.92	2.74	3.68	3.62
2003	4.1	150	11.29	3.29	2.91	2.56	2.66
2004	5	159	16.85	24.95	1.03	6.05	5.90
2005	4.2	156	16.97	21.17	2.64	3.81	5.91

is much deviating from the Indian average rainwater pH of 6.5. Figure 2 shows that the air-pollution was faster after the major industry, Steel plant came into existence in 1989. The just completed International Airport (2009) and the continuous battering of coastal spray may help expedite the 'acid rain' to descend on the city, sooner than later.

With an areal extent of about 200Sq.Km, the city of Visakhapatnam is surrounded by Narava hill on the west, Kailasa hills on the north and Yarada hill on the south. With the coastal spray from Bay of Bengal pushing from east, the city air zone is compressed. The conveyor-belt of the Port rains continuous (day and night) 'dust' on the city from various minerals and materials being exported. The major industries along with the Port, like HPCL, HZL, CFL, BHPV, HPL, CC and ACC, are within a distance of 13 Km from the coast line. The environmental regulation act, stating that two major industries must be separated by a 15 Km distance was violated by planners repeatedly. As if this blunder is not enough, two more industrial units of gigantic proportion, Steel plant and STPC are commissioned in the suburbs of the city. Their impact on the city's atmospheric dust load (Naidu, 2006) will be considerable. An impending acid-rain, as shown by the trends of Ec and pH in Fig. 2, as such, has to be taken into account by all means, as it would affect the health of the environment and the habitants.

CONCLUSION

The average pH of rain water over the industrial corridor of Visakhapatnam has reached an acid-mark of 4.0, indicating the presence of strong acidic ions in Visakhapatnam rainwaters. Fluctuations are superimposed, however, on the declining trend of pH and the increasing trend of Ec, suggesting the role of neutralizing factors of acidity in rainwaters of Visakhapatnam.

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